LEHIGH TECHNOLOGIES

Redefining the Science of Powder Technology

INTERNATIONAL TIRE CONFERENCE

BORDER-TIRE MANAGEMENT PARTNERSHIP

San Diego, California | May 3-9, 2008

from SCRAP TO PROFIT

Implementing Quality in a Ground Rubber Production Facility

May 5, 2008

What is Quality?

Quality is not simply meeting spec and delivering on it –

It is ***consistent delivery*** and ***continuous variability reduction***

Quality in Context

Consistency at a very high level
100% of the time

is better than

perfection 80% of the time and
mediocrity 20% of the time

Quality in Context

Customers expect to adjust around a target – and expect suppliers to adapt to that adjustment – then continue to deliver a matched product ***consistently***

Market Impact

- Evolution of a market = evolution of customers
- Commodity to performance product
- Application expansion as material gains acceptance
  - Sophisticated applications require consistent supply around a standard, as well as limited variability
  - Circular equation of acceptance – quality - acceptance
- Communication of attributes is key

Quality Systems

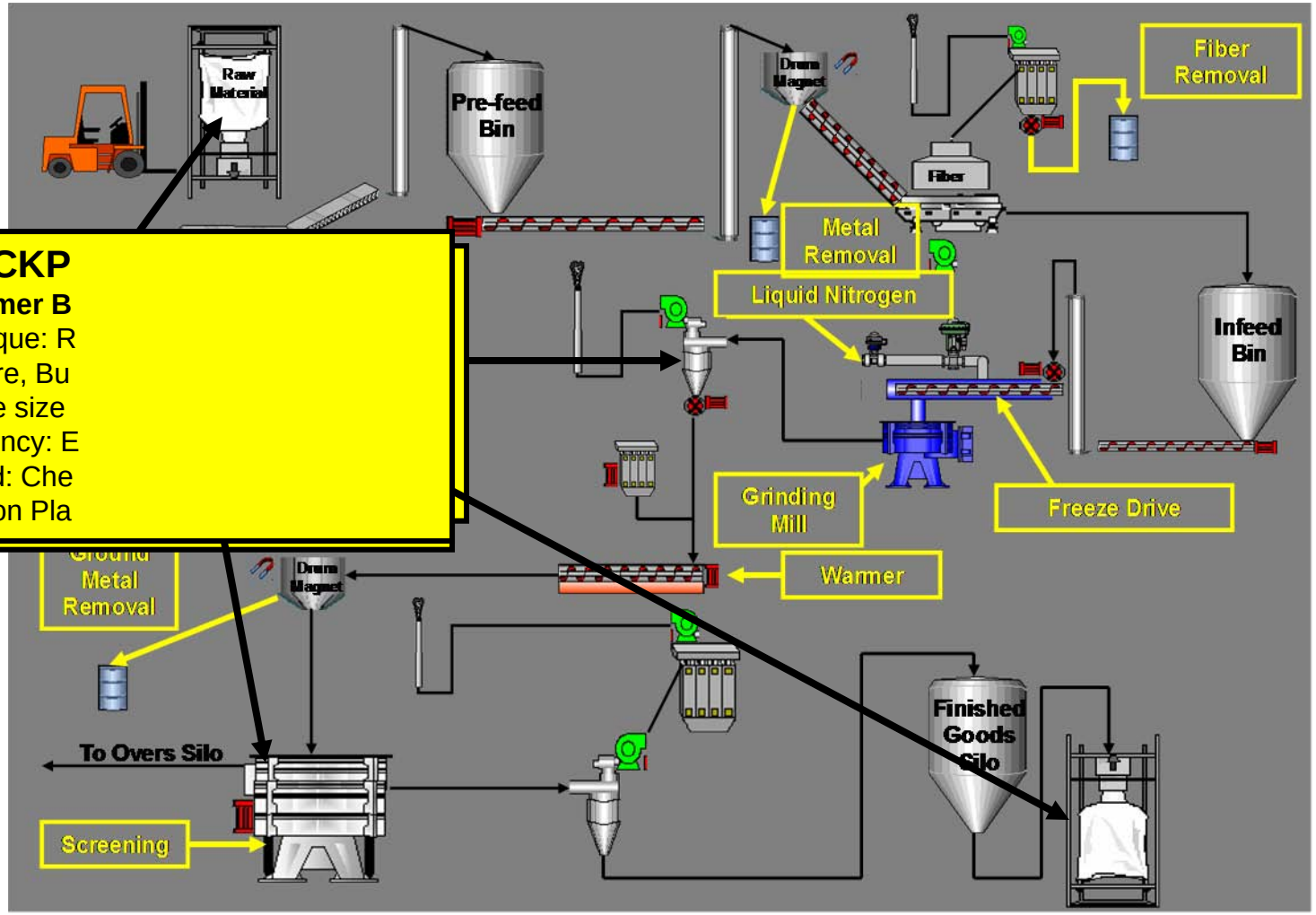
Quality is not incidental, it requires investments in:

- Time
- People
- Process
- Measurement
- Communication – Internal & External

System Components

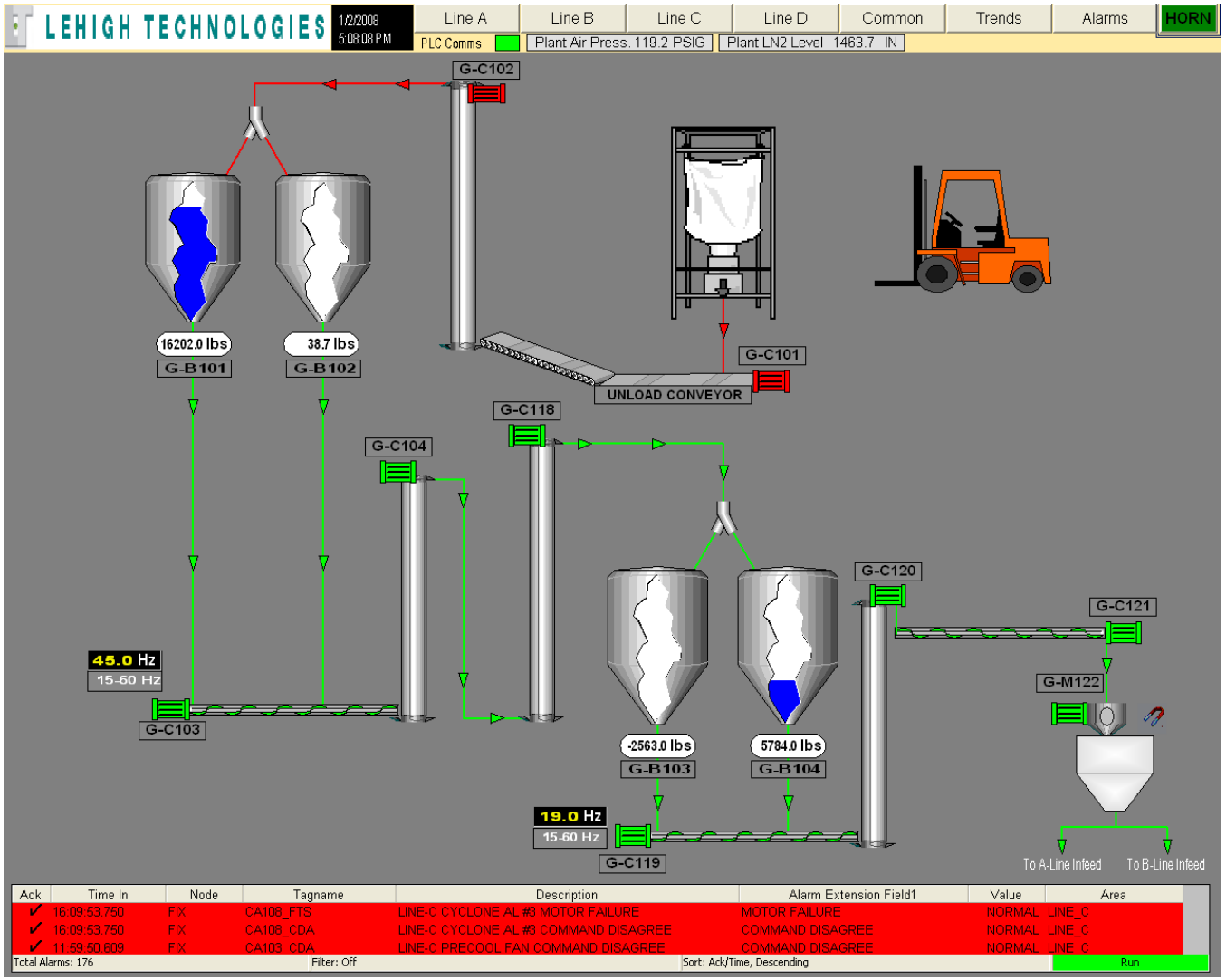
- Process controls
- “Eyes” into the process
  - Monitoring
  - Feedback / Correction
- Variable control
- Traceability

Process Flow

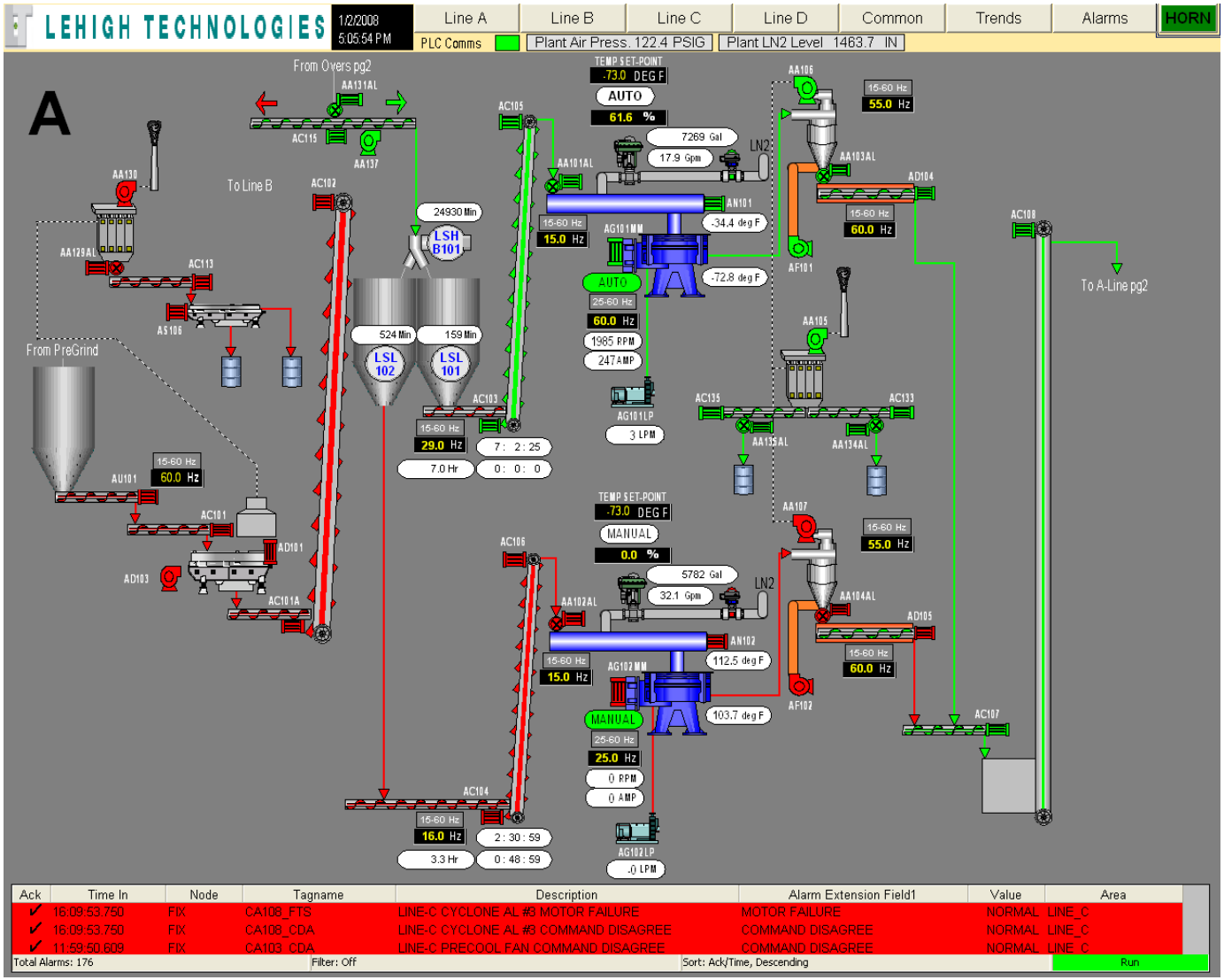


CHECKP
Customer B
Technique: R
Moisture, Bu
Sample size
Frequency: E
Method: Che
Reaction Pla

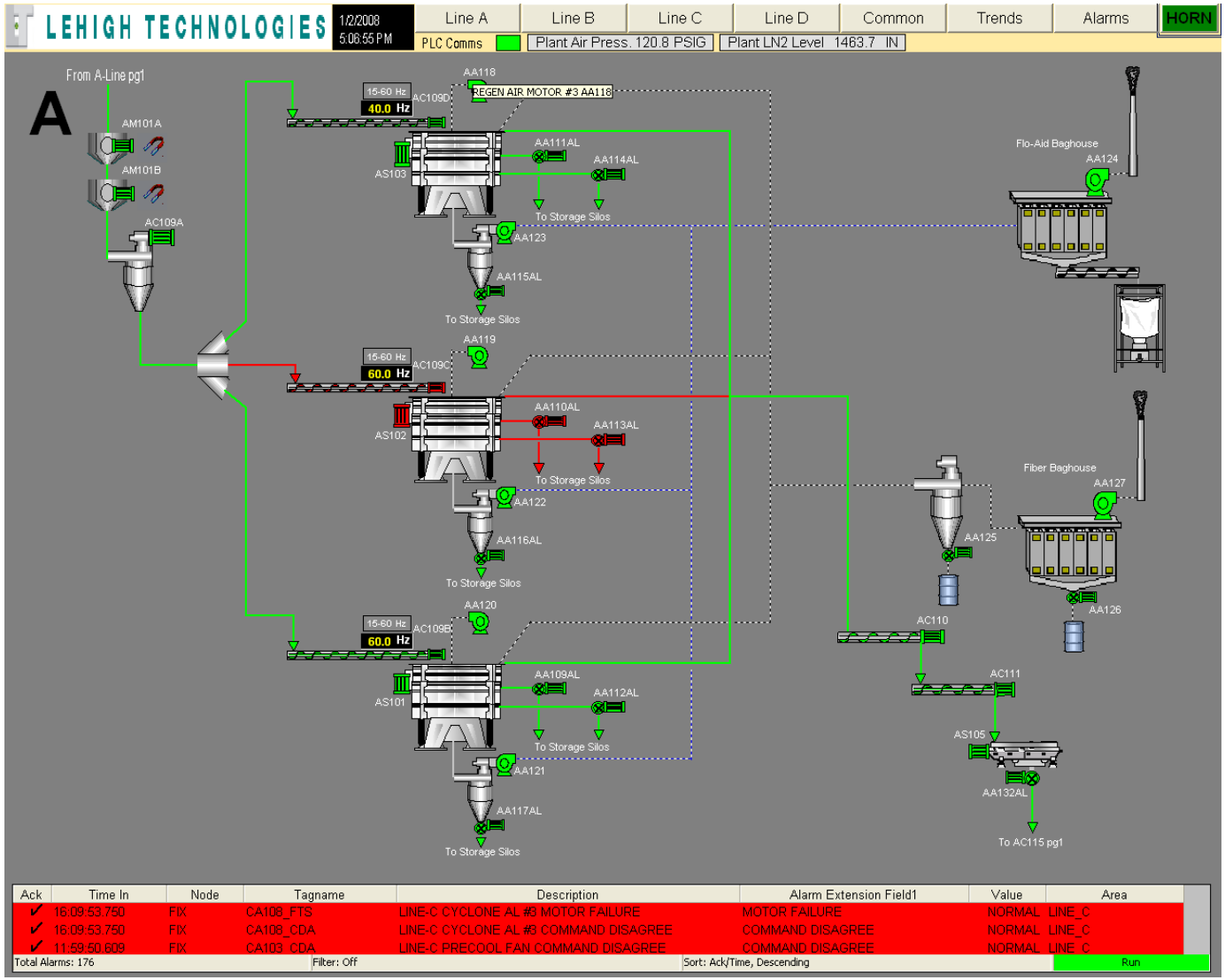
Controls - Pre-Feed



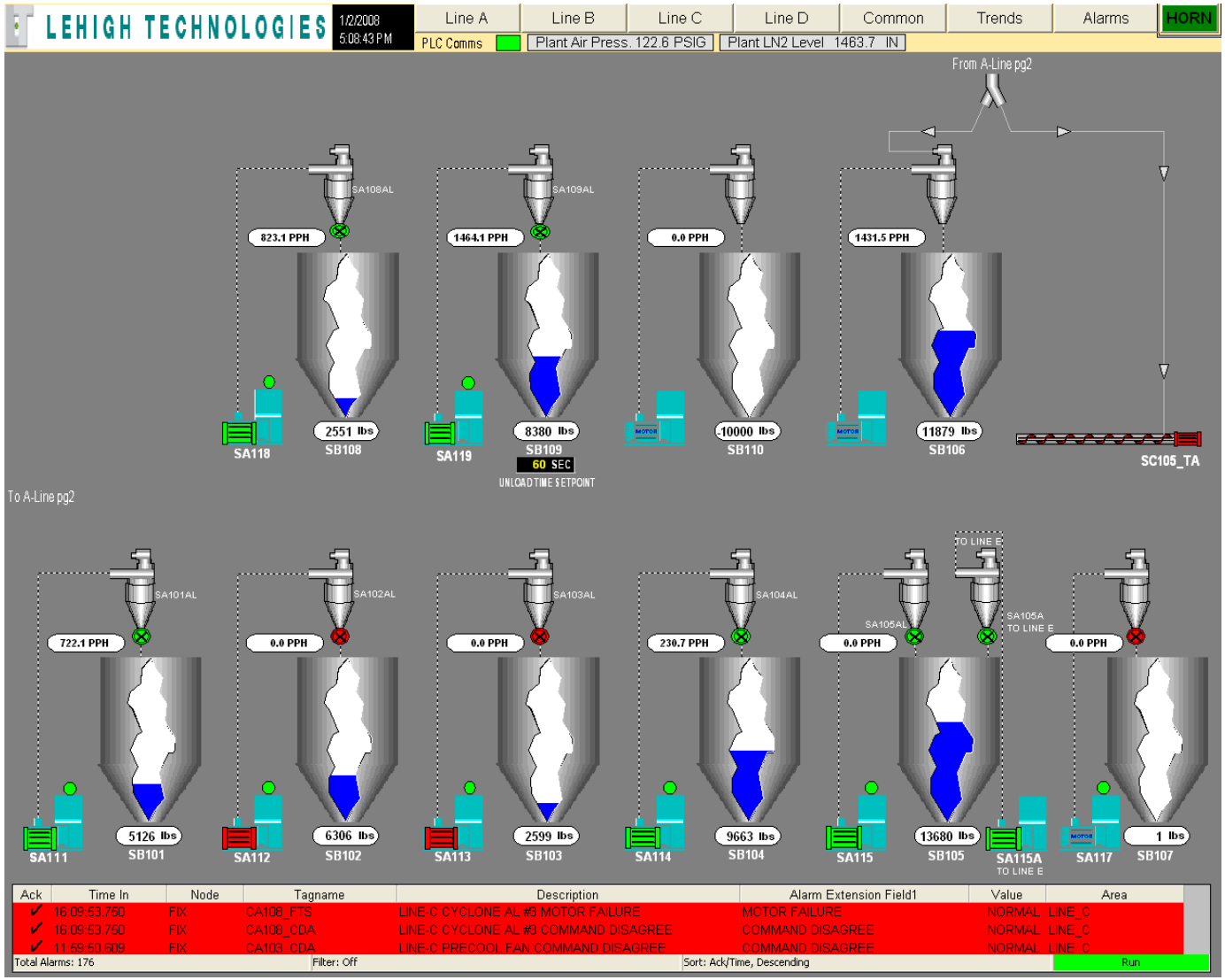
Controls - Grinding



Controls - Screening



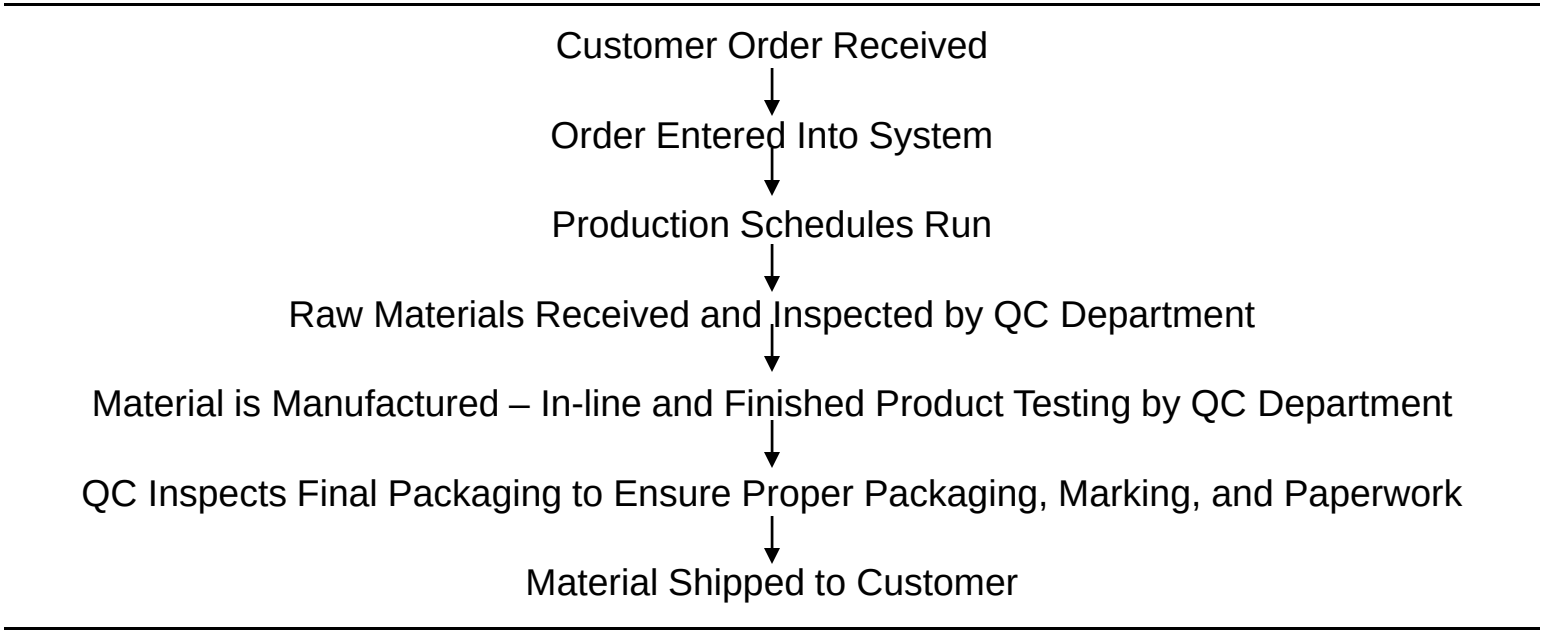
Controls – Final Products Silos



ISO Certification

QA/QC Process Flow

Quality Control Flow Diagram

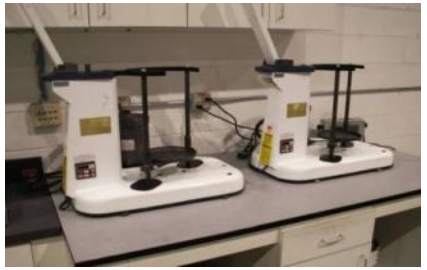


QA/QC - Testing

Testing and Quality Assurance	
Physical & Chemical Characterization	**Equipment**
Particle Size	Mechanical: Sieve Analysis (upto 6 data points) Air: Jet Sieve Analysis (1 data point) Light: Laser Particle Size Analysis (hundreds of data points)
Moisture	Laboratory Moisture Analyzer (with internal scale)
Foreign Material (Fiber and Steel)	Compound Microscope
Surface Area	Laser Particle Analyzer
Flowability & Dispersion	Powder Rheometer
QA/QC Contaminants	Thermal Gravimeteric Analysis (TGA)
Polymer Identification	Attenuated Total Reflector (ATR)
Functional Chemical Group Indentofication	Fourier Transform Infrared Spectroscopy (FTIR)
Chemical Changes As a Function of Temperature Changes	Differential Scanning Calorimetry (DSC)

In-Plant Laboratory

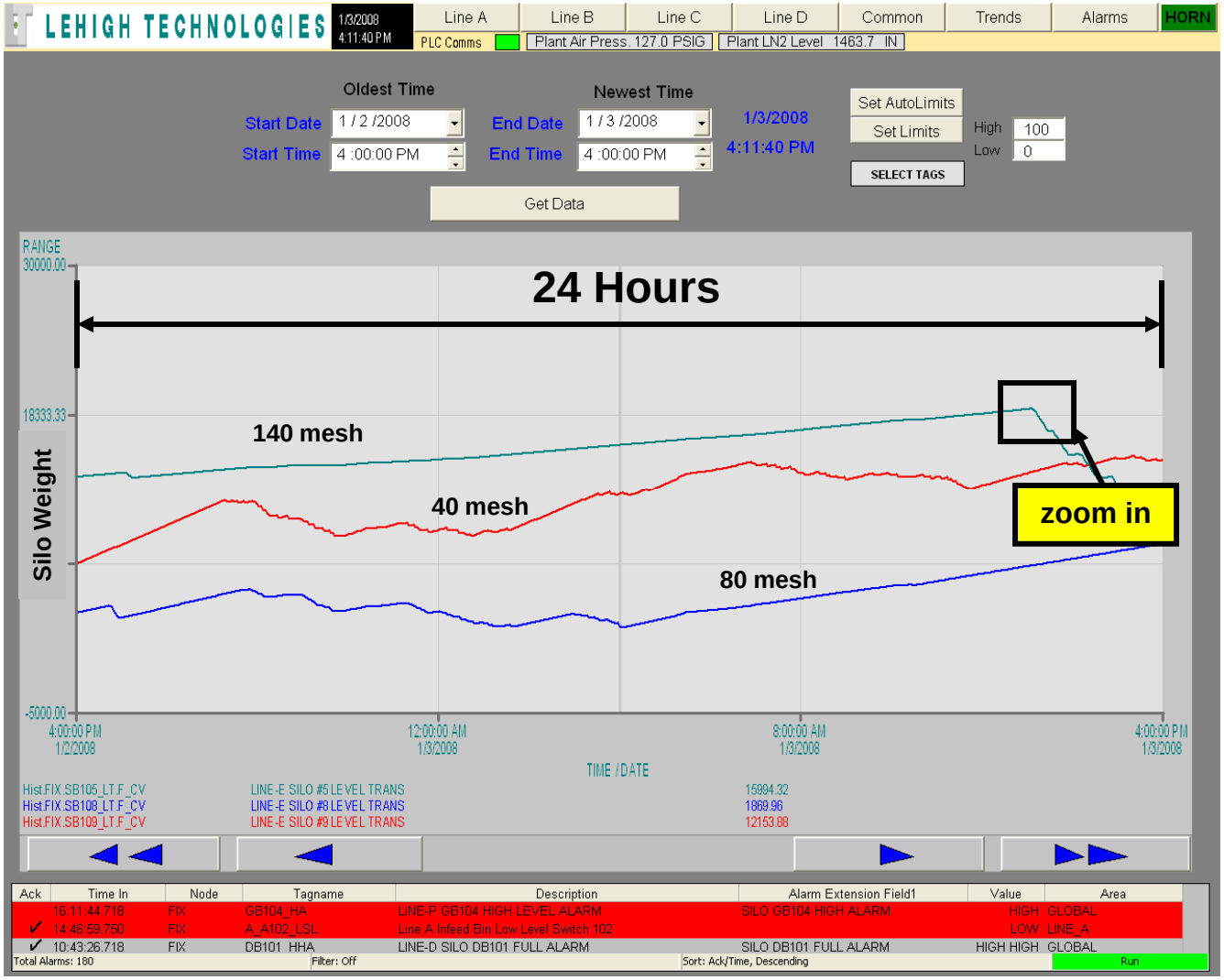
- State of the art equipment
- Continuous staff training
- ISO-controlled procedures
- Certified by leading independent labs
- Certificates of Analysis prepared for major customers



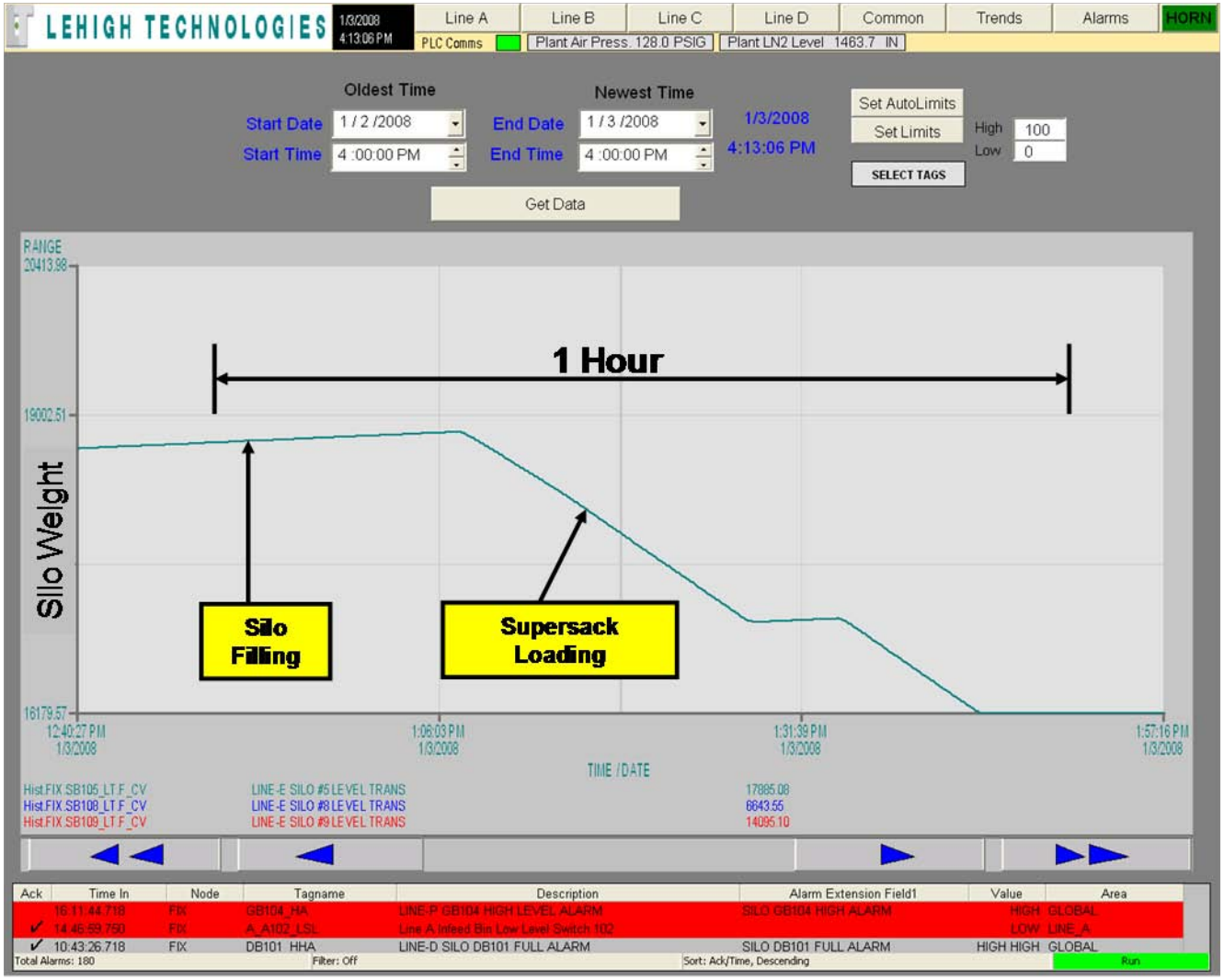
Traceability and Control

- Traceability is fundamental
  - Overall supply chain management
  - Feedstock suppliers
    - Qualification
    - Ongoing standards
  - Production process
    - Characterization / qualification of material inputs
    - Inline production monitoring – feedback loop
  - Finished product testing

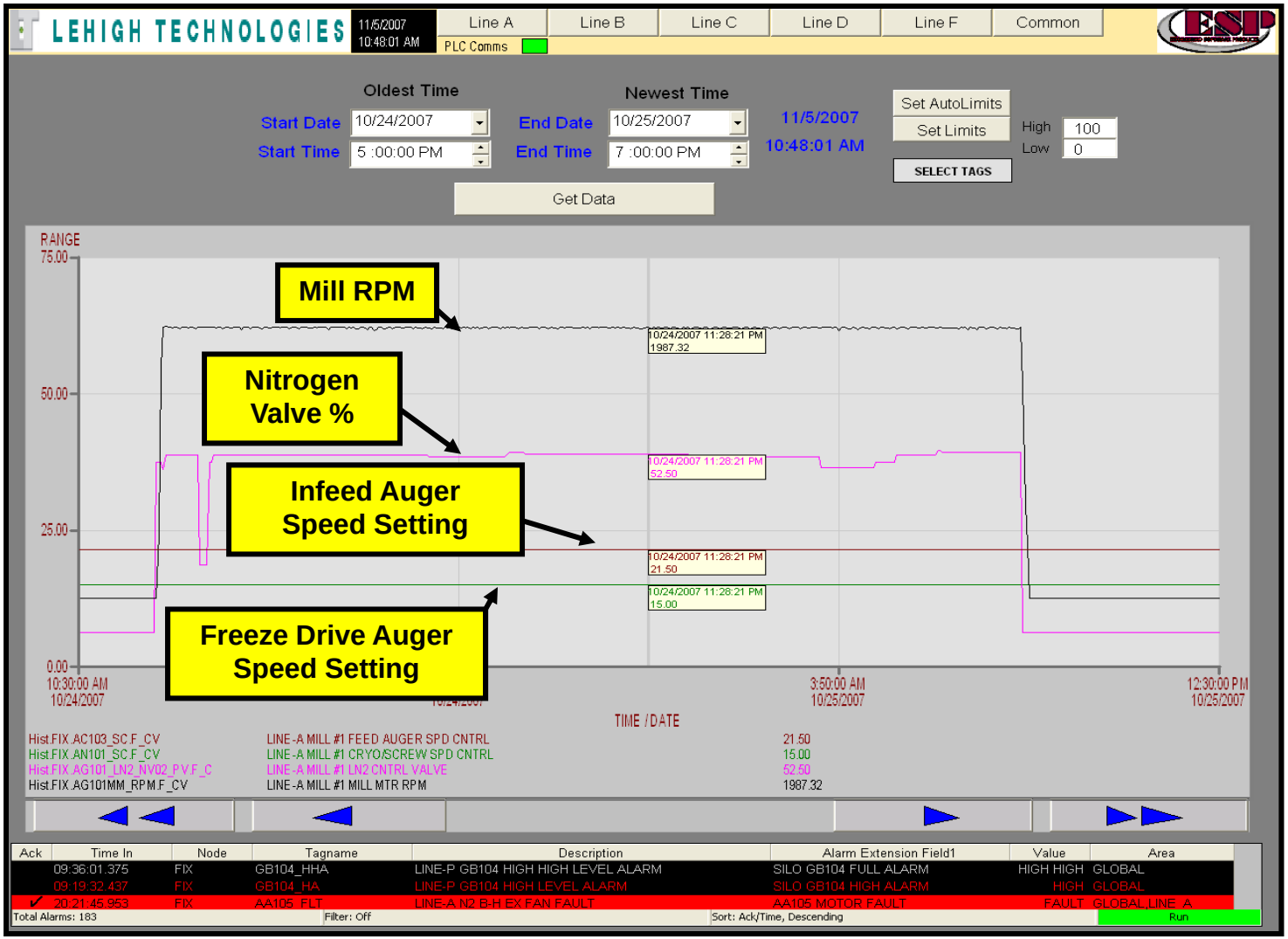
Historical Trending, Finished Product Silo Loads



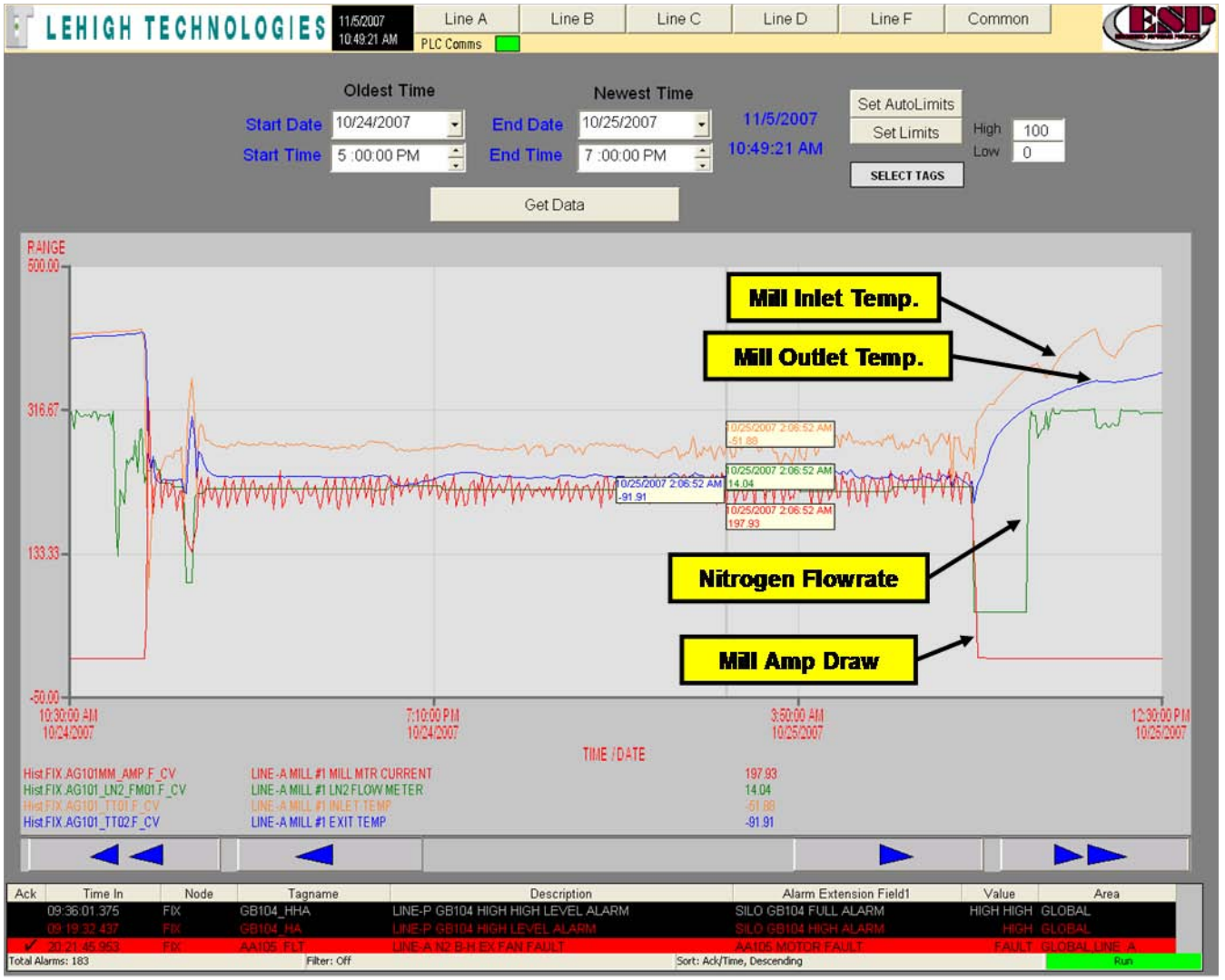
Historical Trending, Finished Product Silo Loads



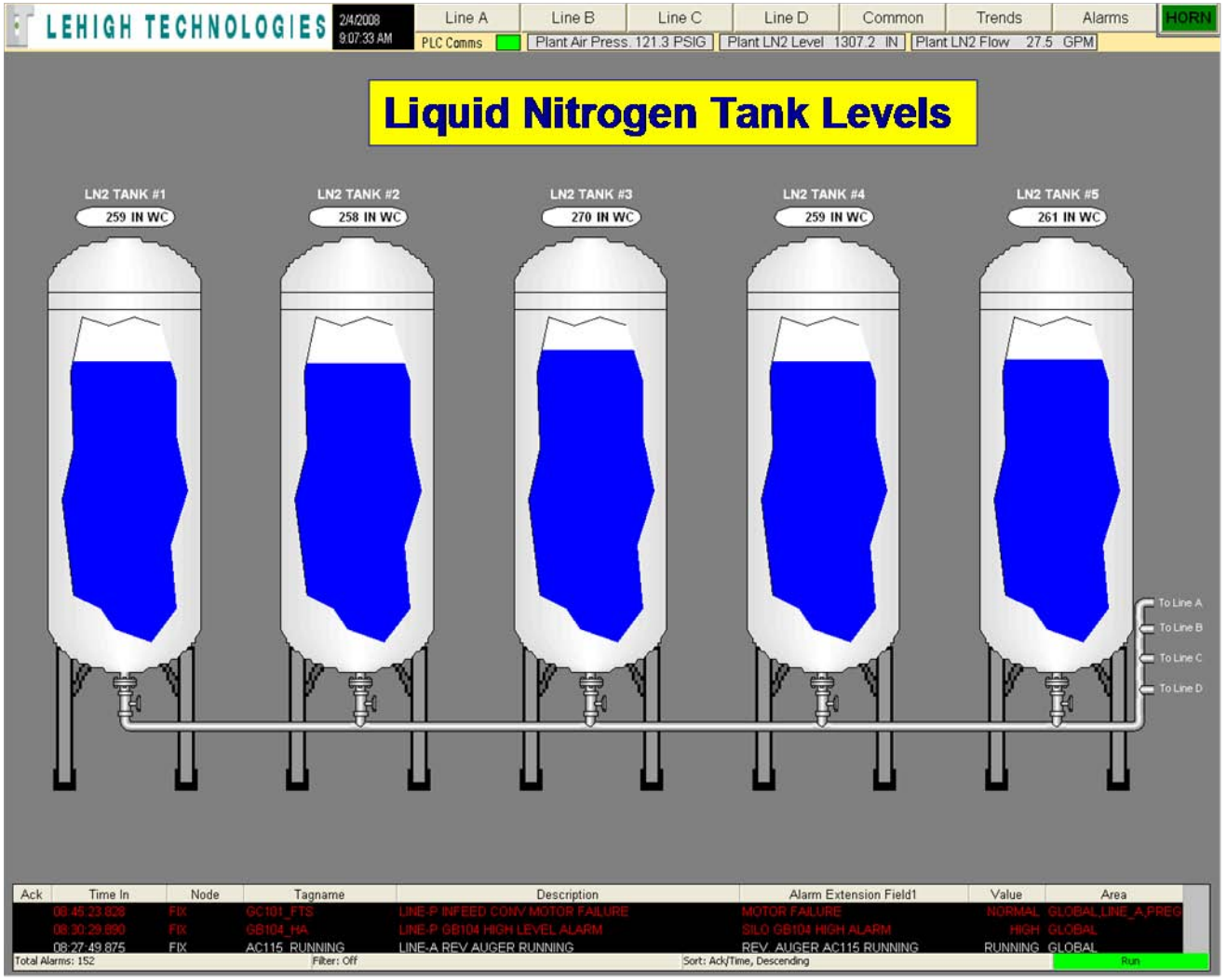
Historical Trending, Mill Input Values



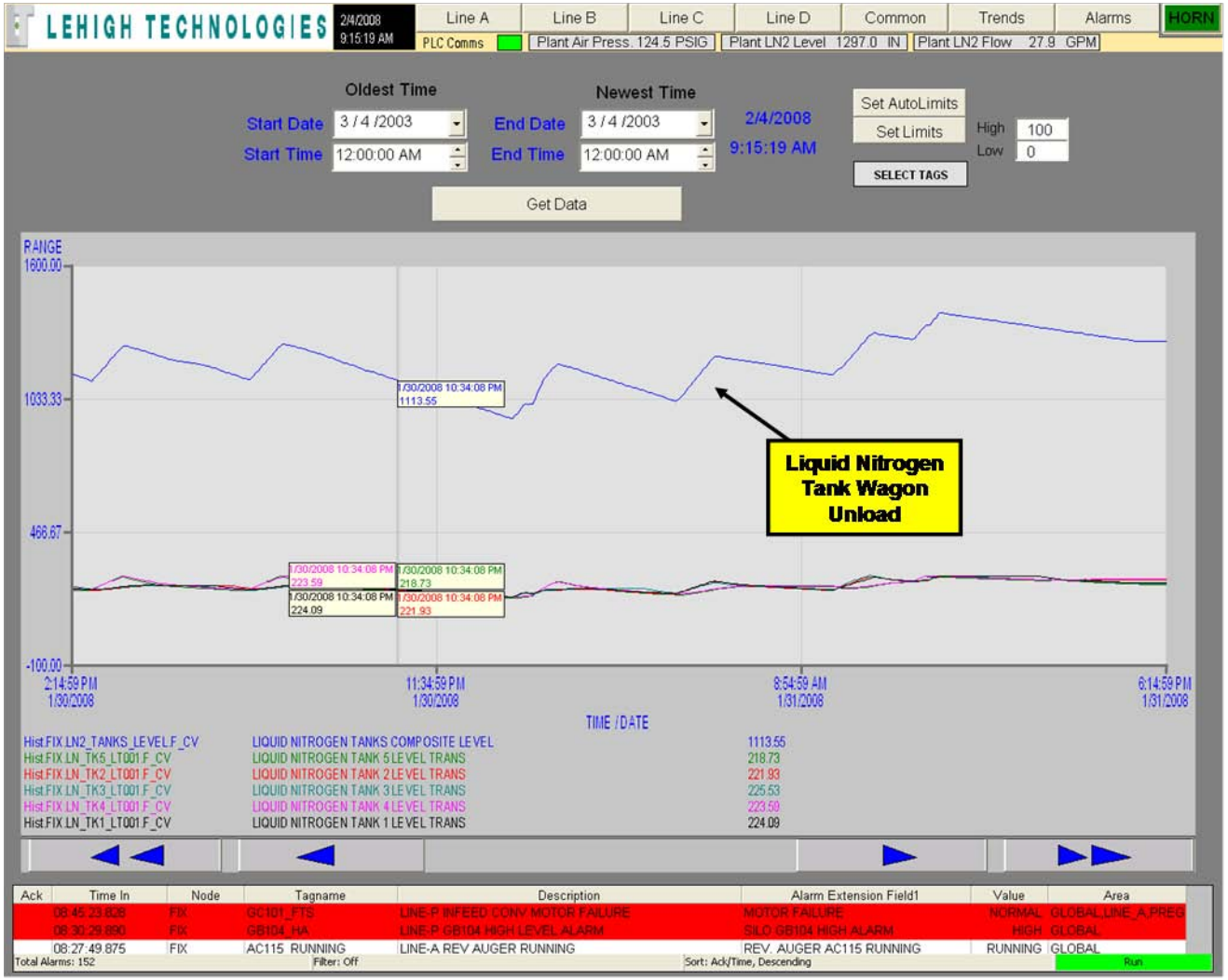
Historical Trending, Mill Output Values



Nitrogen Tank Levels



Historical Trending - Nitrogen Tank Levels



Traceability and Control

- Data collection and monitoring provides ability to control variables and traceability
- Traceability to us means knowing exactly the **process conditions under which a product was manufactured – "process fingerprint"**
  - Delivery of the product expected by the customer
  - Allows for reduction in variability

Continuous Improvement

Improvement Methodology

D.M.A.I.C

D efine

M easure

A nalyze

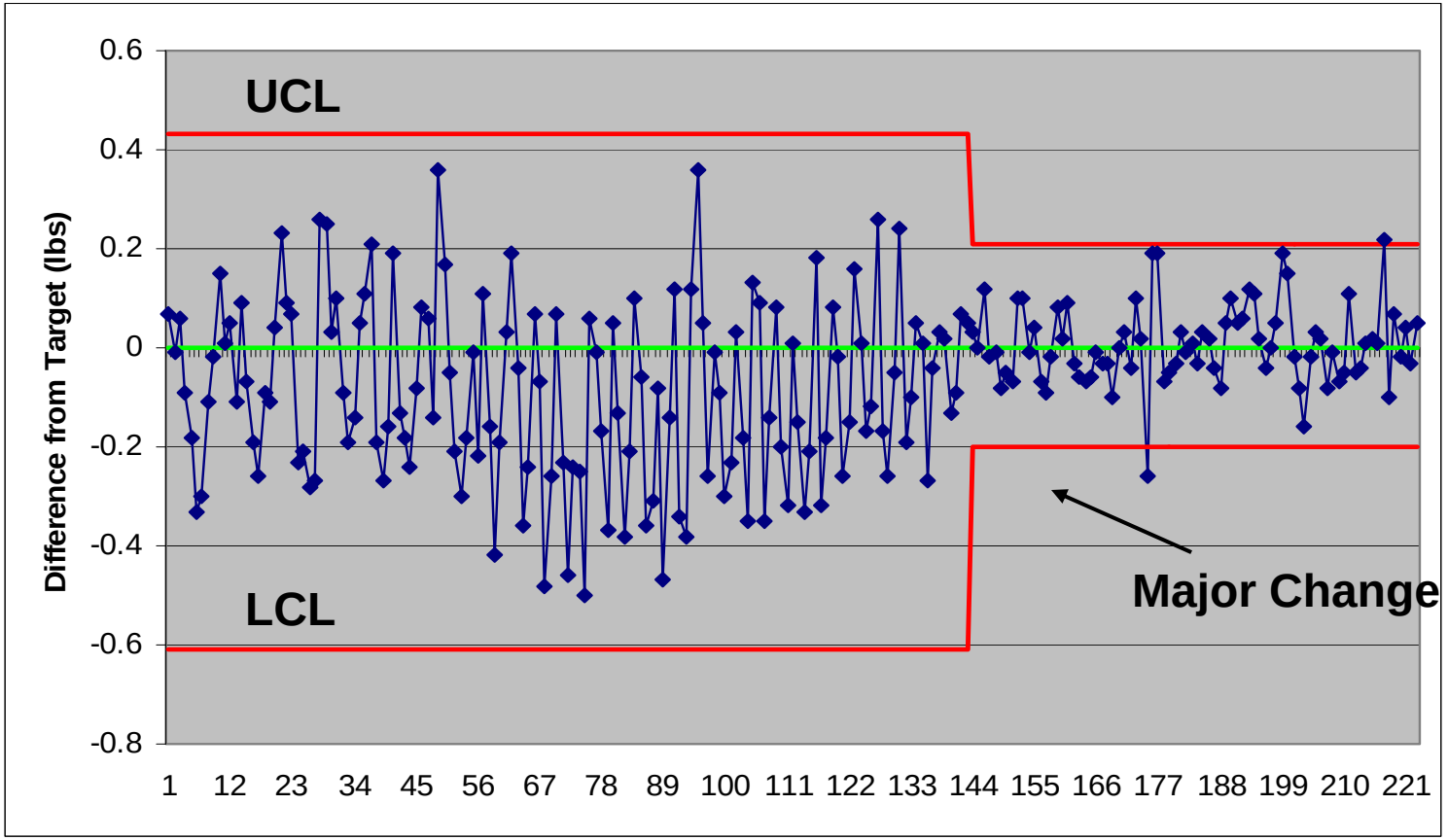
I mprove

C ontrol

Low Melt Bagging Process Improvement

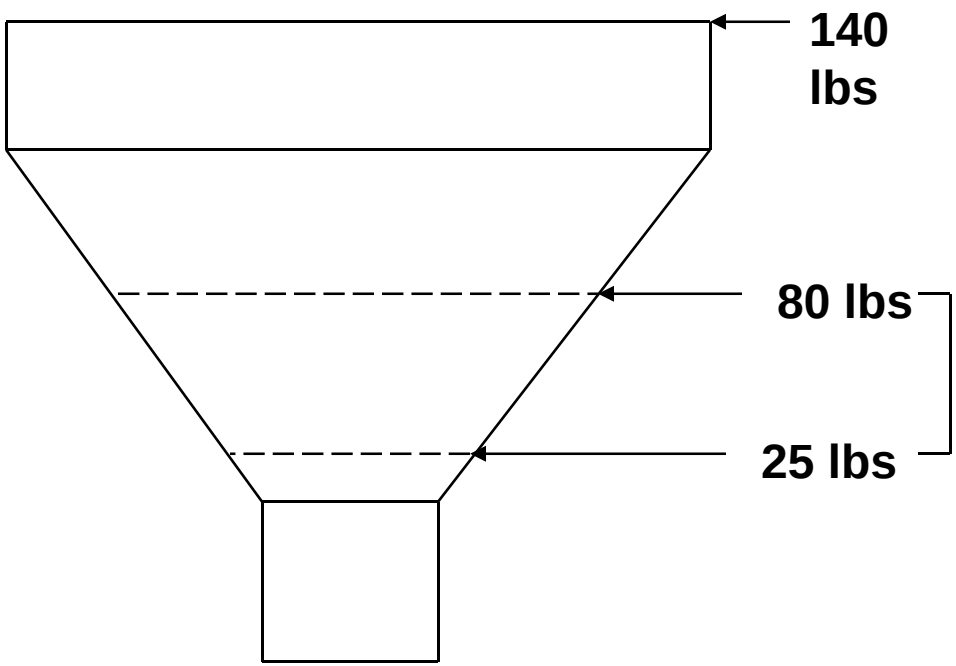
Improvement In Practice

Improvement Based on Weight Differential From Target



Improvement In Practice

Ideal Hopper Level



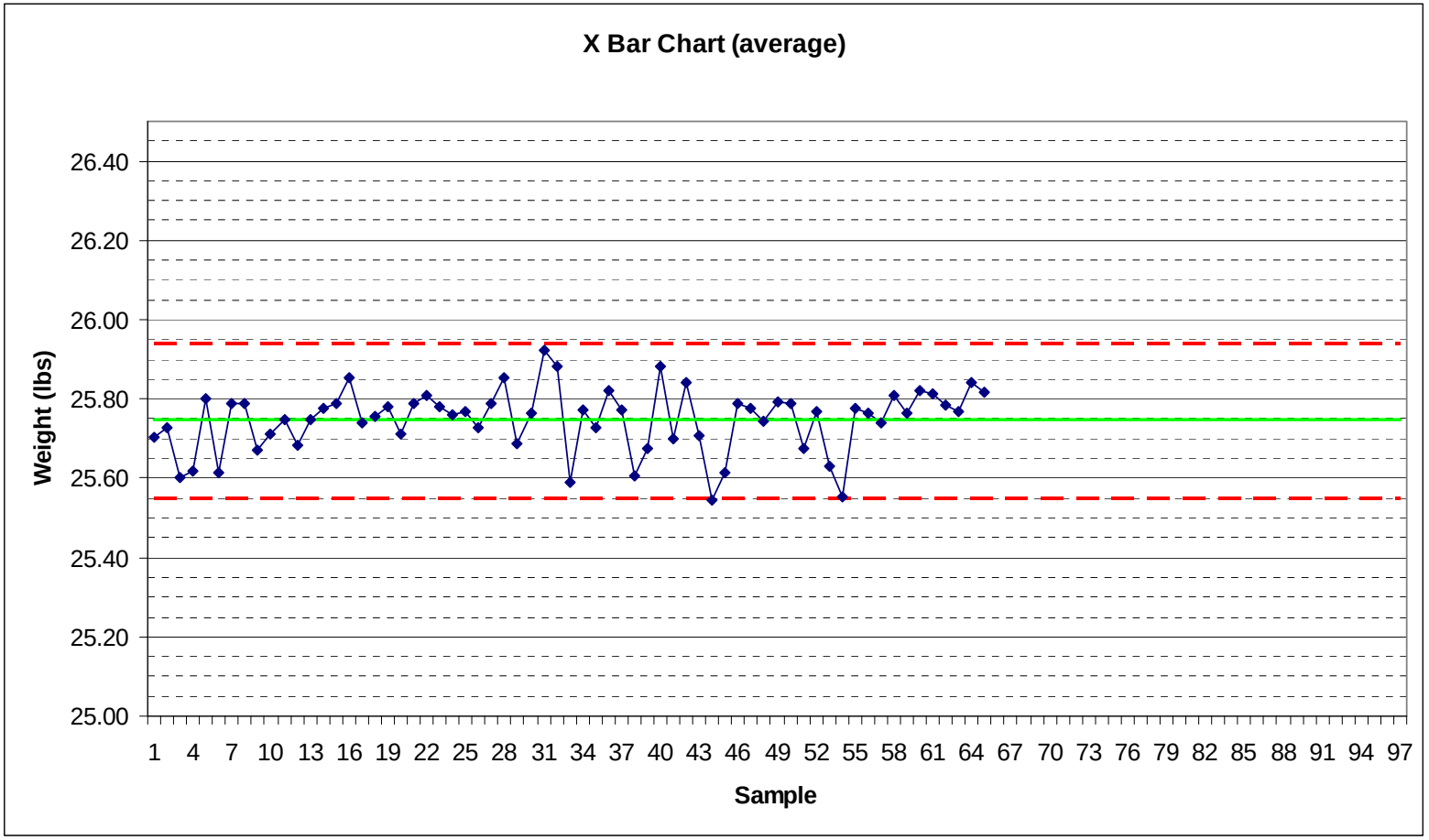
- Determined that hopper level had a strong correlation with accuracy of bag weights
- Ideal hopper weight range is 25-80 lbs
- Accuracy of bag weight is not affected while hopper is filling

Improvement in Practice

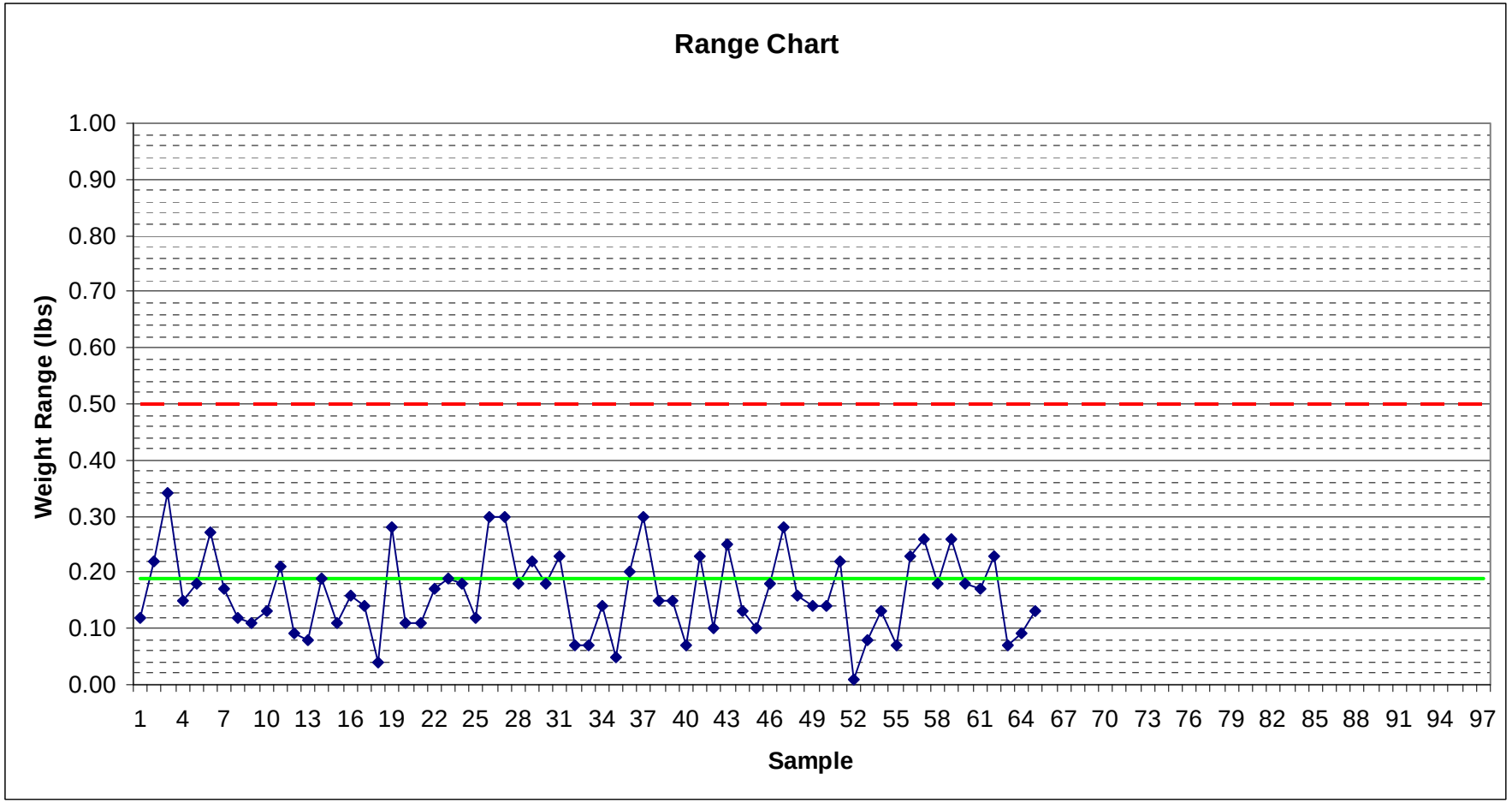
	Before	After
Standard Deviation	0.207	0.08
Bags Out Of Spec	24 %	1 %
Process Capability Rating	0.4	0.99

- Major Changes:
  - Standardize operating procedures
  - Maintain a specified hopper range
  - Hourly quality control checks
  - Scale used to measure weight of material in the hopper

Improvement in Practice



Improvement in Practice



Improvement in Practice

2008 Continuous Improvement Projects:

- First pass yield grinding efficiency
- Liquid nitrogen usage optimization
- Throughput (rate) optimization
- Unplanned downtime reduction

Engineered Rubber Powders

Re-creating New Materials for Industry

Engineered Rubber Powders

- ***Physical Bonding***

  Cavities on the surface are created where the new polymer chains can penetrate

  → physical binding between the polymer and rubber particle

- ***Mechanochemical Bonding***

  Free radicals are formed on the surface of the rubber particles

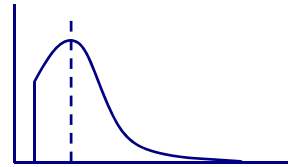
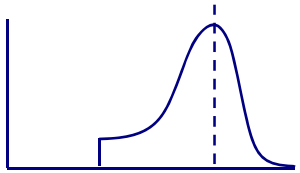
  → these radicals re-combine with the matrix to form bonds

- **Scorching/Heat Build-up is Eliminated**

  In a cryogenic aided atmosphere, the rubber particles are not subjected to the intense heat generated from the energy release by the breaking of the covalent and hydrogen bonds.

  → this heat can degrade rubber particles

Particle Distribution Matters

		Mesh	Mean	Loading Potential
Industry	 80 mesh	“80”	80 - 90	2% - 4%
Lehigh	 80 mesh	True 80	140 - 180	10% - 12%

The finer the particle distribution, the higher the loading possible, the higher the savings

Engineered Rubber Powders

- Controlled Particle Cuts: Over and Fines
- Repeatable, Targeted Particle Size Distributions
- Very Low Moisture and Ash Content
- Targeted Flowability and Dispersion Characteristics
- Below Detection Limit of Impurities: Fiber and Metal

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